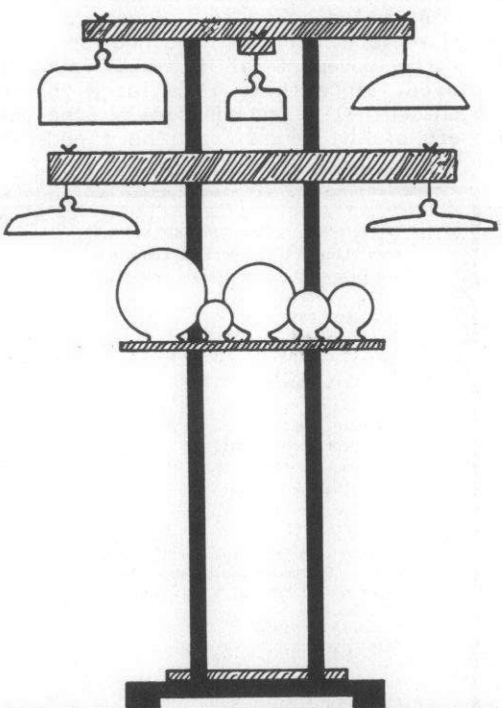
VOLUME III NUMBER 6 APRIL 1988 PRICE 3.50

EXPERIMENTAL MUSICAL INSTRUMENTS

FOR THE DESIGN, CONSTRUCTION AND ENJOYMENT OF NEW SOUND SOURCES



IN THIS ISSUE

Above: Christopher Swartz's Glass Rack -- see page 18.

Welcome to this last issue of our third year of publication.

There are a lot of good things in this issue and, as always, we have found ourselves short of space at paste-up time (EMI may be only twenty pages, but those pages are always packed). So we'll turn quickly to our lead articles. We begin below with a set of pieces on the interesting: esoteric! important? intriguing... subject of fretted instrument liberation.

ALTERNATIVE TUNINGS ON FRETTED INSTRUMENTS -- REFRETTING AND OTHER APPROACHES

An overview by Bart Hopkin, with thanks to Mark Rankin for information on several of the systems described here.

Refretting is the process of removing old frets from the fingerboard of a fretted stringed instrument and putting in new ones. It has long been a standard repair procedure for badly worn frets on guitars, banjos, electric basses, mandolins and such. In recent years it has taken on significance in another connection: some musicians, unhappy at being limited to the tuning system enforced by the placement of the frets on an existing instrument, have taken to removing the old frets and substituting new ones spaced along the neck in accordance with one or another alternative tuning system.

On one level, of course, fretted instruments are tunable: the open strings can be tightened or loosened to produce a continuous range of pitches. But with the placement of the frets such instruments become locked into particular sets of pitch relationships. Once an open string is tuned to a particular pitch, the additional pitches available on the string are fixed by the locations of the frets. Those locations are set by the manufacturer at the time the instrument is made. Not

(continued on page 8)

LETTERS

MORE ABOUT PYROPHONES

CONTINUING AN INVESTIGATION into the origin of the Pyrophone mentioned by Michael Meadows in December, I thought I might share this excerpt from an 1862 article concerning the history of the Glass Armonica by Charles Ferdinand Pohl:

"The physicians speak also of a 'Burning Harmonica.' Strange as this name may seem, it is not inappropriate: individuals who have been present at the burning of the gas of hydrogen are well acquainted with the singular tone produced by this operation, and which has given rise to this strange appellation. The singular phenomenon was discovered at Petersburg, accidentally, and afterwards published by Hauch, in Kopenhagen (phys. chem. naturh. und math), Abhandl. aus der neuen Sammlung der Wissenschaften, ubersetz von D.P. Scheel und C.F. Degen, Kopenhagen, 1798, vol 1, 1st part, p. 55."

Dennis James

PYROPHONE: IF I REMEMBER WELL, singing flames were discovered around 1776, with a hydrogen flame burning at $\frac{1}{4}$ of a tube (lower part). It was called "Chemical Harmonica." Lord Raleigh certainly describes it.

Karcher was a funny man who wrote on different subjects like: military fanfares, Sounds of Nature (from Cicero and Pythagoras Sounds of the Spheres, of the singing mountains of Tibet). His book on Aeolian Harps is basic. Circa 1850.

I certainly have in Paris some drawings of his Pyrophone. I think his trick was to have two flames on articulated shafts. By putting two flames side by side, the sound would come out.

Francois Baschet

ENCLOSED ARE ARTICLES about the Pyrophone in Ginza, Tokyo. It was made by Tokyo Gas Company, a restoration (or copy) of the one in Strassbourg, France (also they are planning to restore). You can enjoy it twice a day (except Wednesday) 3:00 or 6:00 pm at Tokyo Gas Ginza Pocket Park. (I myself have not visited to hear it yet.)

I'm now very interested in Jew's harp. I'll visit mountaineers of Taiwan (Formosa) this February to see their instrument.

Keep up the good work!

Leo Tadagawa

直川礼緒

From the editor: Mr. Tadagawa enclosed two articles in Japanese on the Pyrophone. Shig Kihara of Monterey, California, kindly provided us with this rough translation of one article, augmented by additional information from the other:

THE MAGIC OF FLAMES, THE GAS ORGAN

A very unusual gas organ recital is being presented at the Tokyo Gas Gallery at the Ginza Pocket Park each day except Wednesdays.

Using the only gas organ in the world as a model, the Tokyo Gas Company copied and improved on it. The only gas organ in the world dates back a hundred years and is in a church in Strasbourg, France and is so old that it won't play anymore. So the one in Tokyo is the only operating one in the whole world.

Ordinary organs produce sound by sending air through it, but this one produces sound by the movement of flames. The sound source is the noise of fiercely burning green flames. If the combustion is enveloped by weakly burning red flames, it burns out. In short, if you skillfully use green and red flames, melodies emerge. Organs with heat resistant pipes are used, but since sounds are produced by the movement of flames, fast tunes can't be played. Since there is a large volume of sound, elegant horn-like sounds slowly echo out.

Researchers of the company who have endeavored

EXPERIMENTAL MUSICAL INSTRUMENTS
Newsletter for the Design, Construction and Enjoyment of New Sound Sources

ISSN 0883-0754

Published in February, April, June, August, September and December by Experimental Musical Instruments
P.O. Box 784
Nicasio, CA 94946
(415) 662-2182

Subscriptions $20/year ($27 outside the U.S., Mexico and Canada).
Back issues $3.50 apiece.

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to soften the deafening combustion sounds of gas flames found it most interesting to conduct opposite research into increasing the sound of combustion to a maximum.

Pieces are Finlandia, Brahms Lullaby, Annie Laurie and Japànese Classics. These elegant tunes that take you back to the middle ages are a wonderful relief from the busy routine of modern life.

I WOULD LIKE TO CORRESPOND with anyone who has written/is writing software for just intonation implementation of the Atari 520ST, preferably using the internal oscillators, as I've no MIDI gear.

Thanks.

Jonathan H. Zuber
5010 Murray Rd.
Winston-Salem, NC 27106

JUST RECEIVED THE NEW ISSUE, so I haven't had time to do more than just skim through it... that Photosonic Synthe looks very interesting to me...

In regard to the request by Liz Was (any relation to Was/Not Was?), the spherical clay instrument is called a "Tablita". I saw one a couple of years ago at a local percussion store. It's a pretty interesting "hybrid:" it's part percussive aerophone (like the Palm Pipes), it's part idiophone (one can either "slap" over the holes, on part of the holes or strictly on the body of the instrument, each with a distinctive sound). Also, whilst one hand slaps at the large hole, the other hand's position -- in relation to the small hole -- can be varied, thereby modulating the basic resonance of the chamber. Finally, it's part membranophone (following the same illogic that I had initially applied to the Palm Pipes). Moreover, there are actually three holes: the 2" modul. hole, the 3" main hole (the hole placement is symmetrical, so the instrument could be considered ambidextrous), and the third, smallest hole permits the passage of an audio cable, so that the drum could be mic'ed (or I guess transduced) internally. (I'm wondering now about what placing a small loudspeaker inside and "processing" the output percussively would sound like... that kind of reminds me of the ol' "talking guitar" effect, or also of the chap that uses his trombone as a signal processor.) Anyway, that third hole (1" or so in diameter) could be sealed up and a small amount of water could be used as a modulating agent a la Richard's Waterdrums, etc.

If it hadn't been for the price, I'd have bought it two years ago.

I tried to get the maker's address today, but had no luck. I'd be surprised if other readers do not respond to Ms. Was' inquiry... also, Lark in the Morning may know more.

I'm also sending along a xerox from the book Guitars... by Tom and Mary Anne Evans (Facts on File, NYC, 1977), that describes another approach to folding guitar design...

Bob Phillips

P.S. Is Pierre-Jean Croset left handed, of was the photo/neg. of his Altuglass Guitar reversed?

**

From the editor: Thanks to Rick Sanford of Bractea Instruments we have an address for the Tablita: The maker is Udu Drums, Country Route 67, Box 127, Freehold, NY, 12431; phone (518) 634-2559.

The photocopy from **Guitars...** that Bob Phillips sent along with the above letter shows a brand of travel guitar that we missed in last issue's travel instruments article. It's a folding guitar with what looks like a carrying handle carved right out of the body of the instrument. One notable feature of the Hoyer Foldaxe, as it's called, is a roller pin device which takes up the slack in the strings when the instrument is folded at the neck.

MINNIE BLACK IN THE BIG TIME

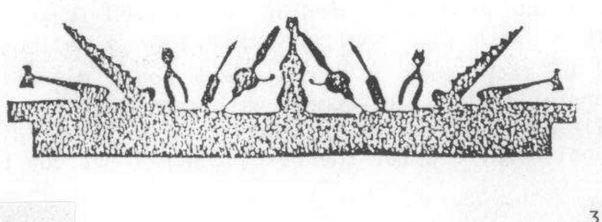
Minnie Black is already well known to readers of EMI as a builder of innovative musical instruments made of gourd, a gourd instrument solo performer, and founder of the Gourd Band, a group of senior citizens performing on gourd instruments. The news is that Mrs. Black has now achieved the lofty status of confirmed nationwide celebrity. Over the last several months, in a flurry of public recognition and appreciation, she has appeared on National Public Radio's **All Things Considered**, TV's **David Letterman Show**, and **The Johnny Carson Show.** Later this spring, Kentucky Educational Television will present a 30-minute documentary on Mrs. Black and her gourd work.

The Gourd, newsletter of the American Gourd Society, describes her successes with a number of quotes from the David Letterman interview, plus her characteristic comment: "Once an old person stops work and starts a-rocking, they soon fall asleep in that old chair, and some of those who fall asleep never wake up....that's why I'd best keep moving."

Mrs. Black is now 89 years old. Her work was featured in EMI Volume II #3, and she and the Gourd Band appeared on our Volume II cassette tape.

CORRECTION

In February's article on the Travielo built by Ernest Nussbaum, we incorrectly gave Mr. Nussbaum's phone number as (301) 530-7356. The correct number is (301) 530-7316. Apologies to all affected by the error.



GRAWI ON THE GRAVIKORD
by Bob Grawi

One of the most beautiful of African instruments is the kora, played in Gambia, Senegal, Guinea Bissau and neighboring countries. A distinctive, sometimes virtuosic musical style has evolved in connection with the kora; it has a fluid, tripping quality in which rapid, lightly syncopated scatterings of individual notes converge to form glittering melodic passages. The instrument is shaped like a large lute, with a cylindrical neck and a big round gourd resonator covered by a leather soundtable. The arrangement of the strings and the playing technique, however, are harp-like. Two rows of strings, with ten and eleven strings respectively, are set in approximately parallel planes. One row can be played by each hand. The tuning is diatonic, with the pitches of the scale distributed in an irregular pattern between the two sides. A unique feature is a pair of handles, one alongside each set of strings, on which the player anchors three fingers while plucking the strings with index fingers and thumbs.

Robert Grawi, author of the article that follows, has taken the kora as the starting point for the design of an instrument he calls the Gravikord. While the Gravikord is modern in construction and far removed from its traditional mentor in many aspects of design, it borrows from the kora a special musical quality arising from the playing technique and the characteristically African divided diatonic layout of pitches.

In this article the instrument's maker describes the Gravikord, its music, and the circumstances that led to its creation.

What comes first -- the instrument or the music? New musical concepts lead to new instruments, new instruments expand our technique and capabilities, leading to new music. This is exactly what happened with the development of the Gravikord. I was always fascinated by the unexpected rhythms in random and free improvisational tribal type music and enjoyed playing the kalimba, or thumb piano. Its divided heptatonic structure somehow struck me at a very deep level. It automatically separated the most dissonant intervals in our traditional scales to spatially opposite sides of the instrument.

As I was understanding the beauty of the kalimba I was simultaneously being attracted to the purity of the sound of a friend's koto and other non-fretted, plucked string instruments such as those of the harp family. I decided to build a harp and picked up a wooden column from a ruined porch to use as the harp column. Then I happened to see an interesting UN film on Africa that influenced the rest of my life. In the movie I saw the kora, an African double-strung harp-lute, and I was hooked. I immediately realized it was a harp -- with the tonal arrangement of a kalimba! All my techniques on the kalimba would directly transfer to this instrument with many more possibilities. I put aside my plans to build a traditional harp, and for the next decade I set out to invent a "better" kora -- which I did -- called the Gravikord.

The real truth is I didn't start out to invent anything. I just thought having a kora would be great. The kora, unfortunately, was a little known instrument, part of the folk-griot society of western Africa. It was just what I was looking for, but try to find a good one, or one that is easy to tune, or one that does not go soggy on a humid day. When I looked, all I saw were "tourist instruments" -- things that looked kind of musical but were just made to hang on your wall.

But I wanted to see a real kora -- how it was made. I knew about the musical instrument collection at the Metropolitan Museum of Art in New York City. I went thinking I could see one. The collection is very broad and contains instruments from all over the world from different historical periods. This is a great resource for anyone interested in instruments of other periods and cultures. You can imagine my surprise when I could find no kora on display. I couldn't believe they didn't have one. I personally asked the curator if they had a kora and he said:

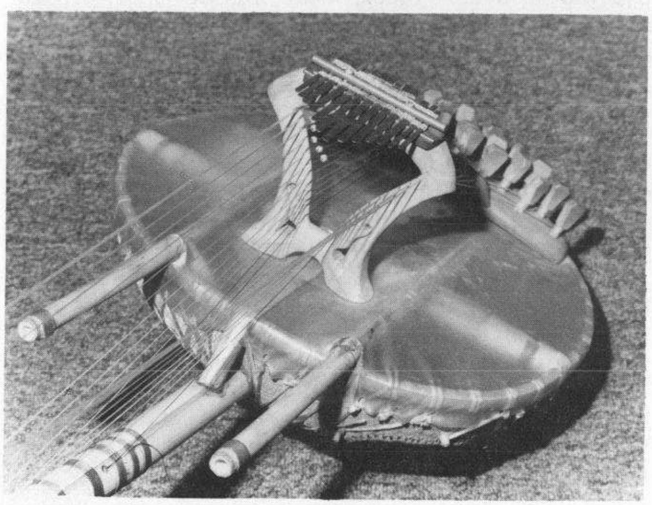
"Yes, but we keep it stored in the basement."

"Well, couldn't I see it?"

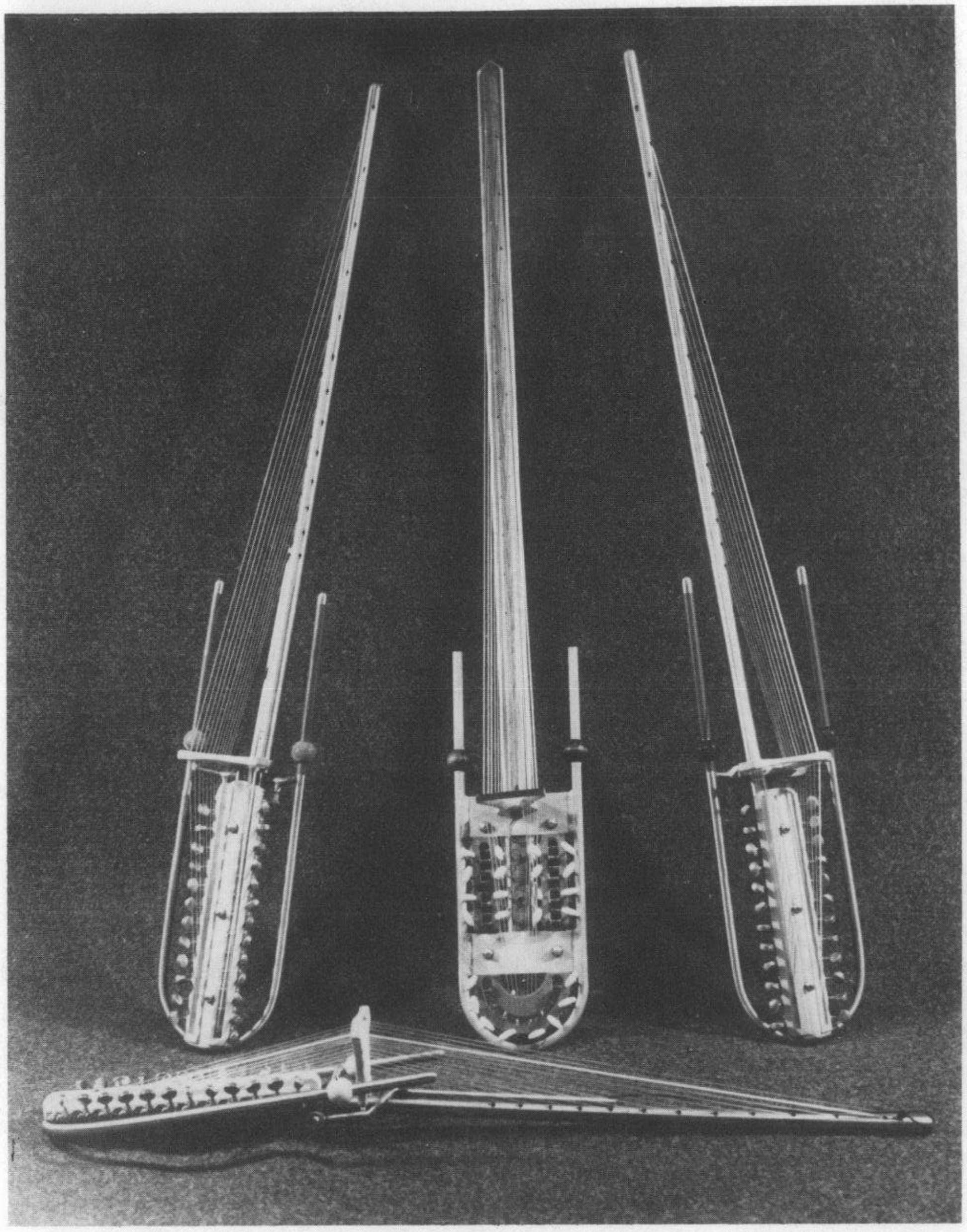
"No, I'm sorry -- you're not doing official academic research."

I explained my serious interest but the answer was still negative. So I did the one thing I could -- I built my own.

The kora is built around half of a gigantic calabash gourd about the size of a large pumpkin. Apparently these are common in western Africa, but not in New York City! They tend to be imported as carved art objects with correspondingly inflated prices. For my first model, all I wanted was a gourd in the rough. The solution I came up with was to use a cheap Chinese woven basket as the resonator. This, after applying fiberglass mesh and resin to the inside, became a beautiful gourd-like resonator. Another innovation in my original instrument was an open inverted triangular bridge with metal kalimba keys incorporated across the top. This truly "bridged" the gap between the



The Missing Link: basket & fiberglas kora with kalimba bridge.



kalimba-kora-Gravikord -- an evolutionary missing link.

After experimenting for several more years, I finally arrived at the instrument that I play today. The current model is no longer the kora -- but a descendant. To create the Gravikord, I added more strings. For a while I played a 25 string instrument, but the current Gravikord I make for sale has 24 strings, which I find full and sufficient to span a 3½ octave range by my method of tuning. I find it essential to go to the third above the root in the treble, and in the bass to have one note, the 5th of the scale, below the root. In between there are three full diatonic octaves. The kora is tuned by moving thongs, to which the strings are fastened, up and down the hardwood neck. I installed modern metal tuning machines in a tuning block assembly at the base of the neck, in a convenient position on the instrument. This also results in a perfect weight balance of the instrument at the player's hands. The tuning machines are protected by the "U" tube extension of the handles. The hands hold the handles in a more normal fashion than on the kora. Resting on the large beads, one hand on each handle, the base of the instrument between the player's legs, this is the natural sitting position, with arms slightly elevated. The handles are raised and shortened relative to those of the kora, and the bridge has been radically redesigned. The idea was to "ergonomically" redesign the instrument in such a way that it would "disappear" as much as possible. In other words, I tried to remove as much awkwardness as I could.

The structure evolved from bamboo to wood and aluminum and I finally settled on a light welded stainless steel frame. Stainless is strong, lightweight and beautiful. This frame is basically indestructible -- it is all stainless --not a plated metal, so any surface damages are easily refinished. The new bridge went through many refinements before a lively treble and bass response was achieved. It had to be designed to maximize internal vibrations while standing on a stationary platform. I learned that tall bridges like the one I was working on and those on violins, cellos and basses can be thought of as complex systems of wooden "springs"

Above: Several prototype GRAVIKORDS.

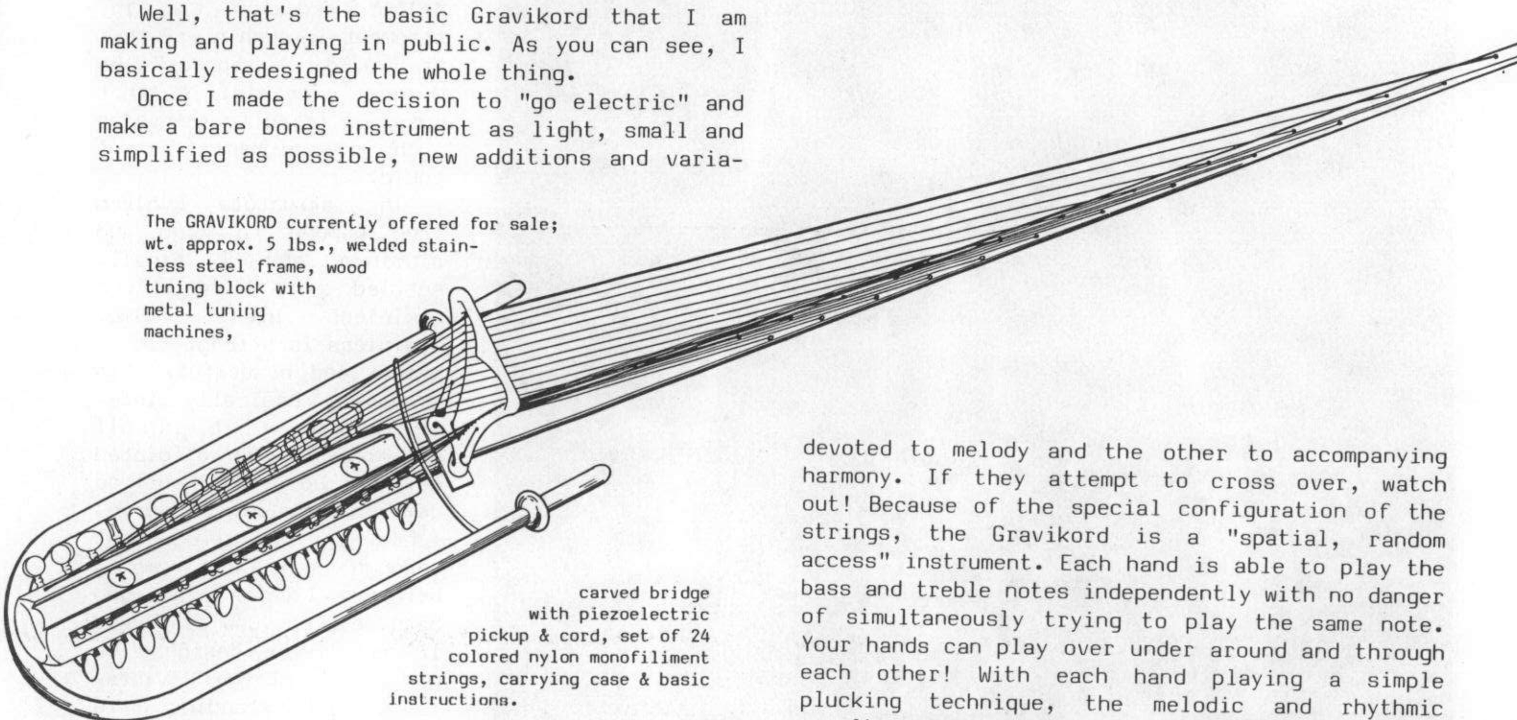
Right: The author with gravikord in playing position.

and inertial masses. By subtly adjusting the design of the "springs" and the size of the inertial masses the vibrational response can be manipulated. This is complex and really could be the subject of a separate article.

The inter-string spacing on the Gravikord has been reduced to about one-half the spacing on a kora. This facilitates more fluid strumming although it makes fingernails essential. A piezoelectric pickup is incorporated in the bridge design and the vibrations are sent to a separate amplifier.

Well, that's the basic Gravikord that I am making and playing in public. As you can see, I basically redesigned the whole thing.

Once I made the decision to "go electric" and make a bare bones instrument as light, small and simplified as possible, new additions and variations suggested themselves. Why not add a dampening bar controlled by the player similar in effect to a sustain pedal on a piano? Could a variable pitch model be constructed? Why not soprano - tenor - bass Gravikords? At present I've constructed prototypes of a variable pitch Gravikord in which the bridge is mounted on ball bearings and a lever system so that it can be raised while being played; a small soprano variable pitch instrument; and several different tone control bridge dampening devices. I've also designed quick retuning devices which clamp on the neck similar in effect to the levers on some harps. As you can see, it was a fruitful vein.



The GRAVIKORD currently offered for sale; wt. approx. 5 lbs., welded stainless steel frame, wood tuning block with metal tuning machines,

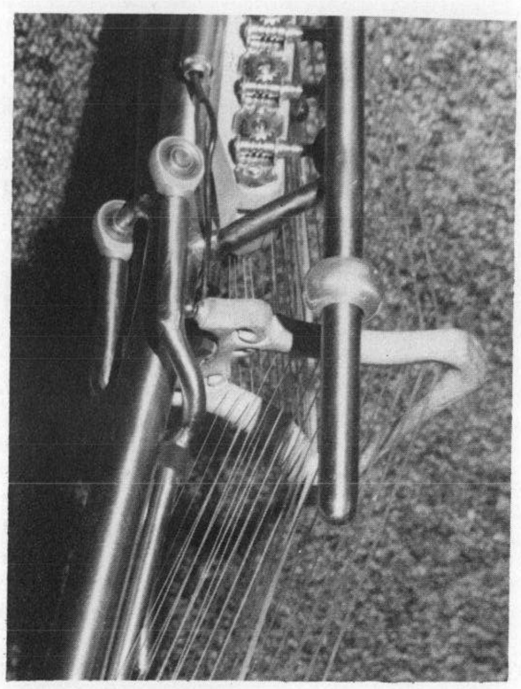
carved bridge with piezoelectric pickup & cord, set of 24 colored nylon monofiliment strings, carrying case & basic instructions.

Run your fingers through a large random cluster of bells and try to imagine producing the same rhythms and melodies with a totally conscious effort. If you continue with the right attitude -- an attitude of conscious-unconscious cooperation -- the amount of control-noncontrol you can develop will approach the magical.

It was experiences and desires like these, simple techniques leading to complex unexpected results that led to the development of the instrument. It's also the way I perceive the music I play on the Gravikord. In most of our traditional instruments there is no place for the irrational non-conscious mind until fluid mastery over difficult techniques are developed through years and years of training. The "non-musician" is denied access to this satisfying level of experience. Our instruments are linear right brain structures.

But I was not satisfied with a jumble of bells. I wanted a pure beautiful harp-like sound. A harp yet not a harp. A harp, like a piano, is a "linear, Euclidean instrument." Mostly one hand plays bass and the other, the treble, so one hand is devoted to melody and the other to accompanying harmony. If they attempt to cross over, watch out! Because of the special configuration of the strings, the Gravikord is a "spatial, random access" instrument. Each hand is able to play the bass and treble notes independently with no danger of simultaneously trying to play the same note. Your hands can play over under around and through each other! With each hand playing a simple plucking technique, the melodic and rhythmic results can be complex, intricate and unexpected.

Also, basic chords like a I chord (root, 3rd, 5th) are already separated out and lie on adjacent strings, which are always in pleasing intervals. For example, in the key of C: the B - C and E - F intervals are not right next to each other as they



Detail of mechanical parts of soprano Gravikord, including an experimental pitch-changing lever.

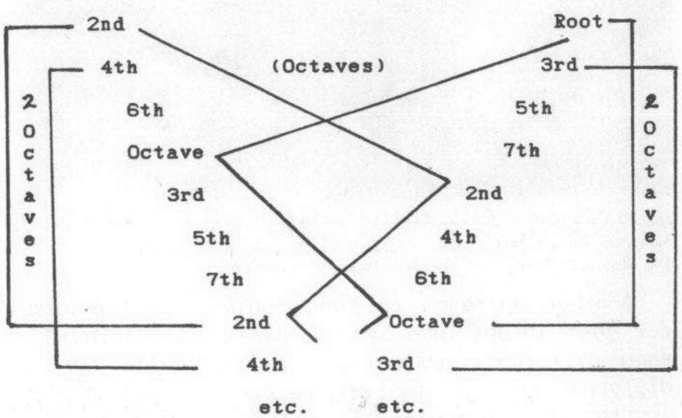
are on the piano, but are actually as far apart as possible on different sides of the instrument. I use several tunings on the instrument myself and do not wish to dogmatically pronounce what is the "correct" tuning. As a basic tuning, I recommend the following diatonic tuning in ascending order for the Gravikord, as string length, gauge and tension have been designed for this range.

Left hand:
D (2 D's below middle C), C,E,G,B,D,F#,A,C,E,G,B.

Right hand:
G (2 G's below middle C), B,D,F#,A,C,E,G,B,D,F#,A.

Note: This is not a kora tuning.

A normal diatonic scale on the Gravikord is arranged as below:



Octave spacing is constant up and down the instrument. Songs are imbued with a spatial content and individual symmetry analogous to using a push button phone versus a rotary dial. In the player's mind, the musical compositions come with an additional geometric dimension. In improvisations the patterns suggested can be quite liberating. Often times, the left hand does not know what the right hand is doing -- but the ears don't care and integrate it all into a musical whole. It's like holding on and letting go at the same time. The more you play, the deeper and more natural becomes your understanding of this. Listen to the Gravikord -- it will lead you on. With it more than with any other instrument, you can be your own teacher.

I began playing in public and strangers came with cameras in hand taking close-ups. After ten years of development on my own, I decided to get a patent so I wouldn't have to worry who was taking pictures while I was playing in public. Two patents later, with others still pending, my company, White Bear Enterprises, is starting to market both the instrument and the music.

And what is the music like? Sounding like an electric harp with a built-in bass, the Gravikord has a sweet acoustic quality made deeper and richer by the sympathetic vibrations of the unplayed strings. I've come to believe that there will be as many different styles of playing the instrument as there are individuals playing. My own style evolved from the kalimba and therefore it contains a lot of the polyrhythmic qualities. I like to refer to it as a new kind of American ragtime and I play a lot of traditional folk and improvised melodies.

We are surrounded by rhythms -- within and outside of us they flow over and through us all. I like to play with the rhythms of nature in the music ...a river flowing to the ocean, thunder clapping, or snow falling under a streetlight. I try to capture a small portion and mix it up with our culture and let it out musically. For me, with the Gravikord it's easy. I don't play music with a capital M, but maybe that's why so many different people respond. Young and old, classical violinists and rock musicians -- even people who tell me they've never been musical -- are drawn to the instrument and my music. It is always a great joy for me to see a "non-musician" attracted to and playing the Gravikord for the first time. It's Christmas for us both.

I have been an artist and a builder but I have found nothing more satisfying than making this musical instrument. After it's finished, it's really just begun. I loved polyrhythmic music and was able to create the Gravikord and to make its design as beautiful as the music.

I'm involved with the Gravikord for life -- for better or worse. It doesn't matter to me how successful an enterprise it becomes; it's a part of me. Its magical and mysterious qualities are an end in themselves.

When I first picked up the Gravikord, there were no teachers. It was like learning to walk and every step took me to a new place. Even now, after many years, when I sit down to play, it's still a mystery, it's still magical.

****

For more information on the Gravikord, please contact:

White Bear Enterprises
247 W 16th St.
New York, NY 10011
(212)463-9180

Cassette tapes are available for $8.95 plus $1.50 shipping.

Drawing by Hal Rammel, from Song of an Aeropteryx

REFRETTING, continued from page 1

surprisingly, with almost all commercially made instruments the fretting is set for twelve tone equal temperament. Fretted instrument players interested in other intonational systems find themselves searching for ways around the factory-standard tuning, and this has led to the current interest in refretting.

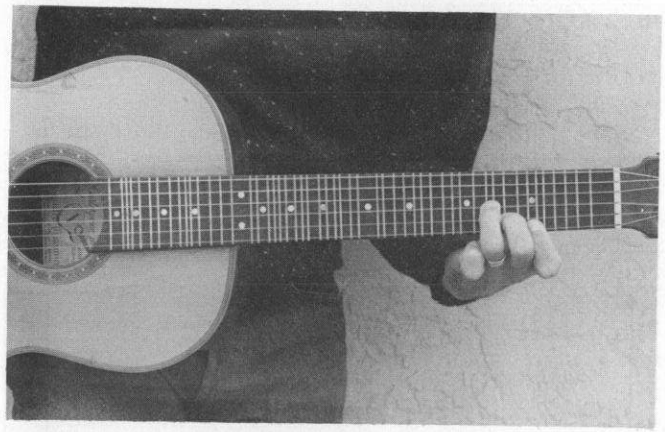
In the article that follows, Buzz Kimball provides practical information on refretting procedures and some of the reasoning behind them, with an emphasis on refretting to higher order equal temperaments. Appended are fretting tables (used for calculating fret locations) for some of the most common non-twelve equal temperaments. Buzz has been exploring equal temperaments and just intonations, including some rather unusual and exotic systems, for many years. During that time has refretted a great many guitars.

There are a number of other people currently involved in refretting and related approaches to fretted instrument liberation. Before going on to Buzz' article, we will look at the work of some of them in the paragraphs that follow.

One of the people most active in refretting -- both in practice and in advocacy -- is Ivor Darreg. His articles on the subject in the February 1978 issue of **Guitar Player** and the Fall 1979 issue of **Interval** were among the first published discussions of refretting to non-twelve systems, and they remain interesting and informative now (address for **Interval:** PO Box 8027, San Diego, CA 92102). Ivor Darreg is also a good source for fretting tables for wide variety of tuning systems, with an emphasis on higher order equal temperaments. Write him at 3612 Polk Ave., San Diego, CA 92104.

One of the reasons that both Buzz Kimball and Ivor Darreg emphasize equal temperaments is that there are some difficulties inherent in applying the unequal divisions characteristic of just systems to a fretted instrument with several strings. To illustrate this: a fretting pattern which provides a just scale in G when lying under an open string tuned to G will provide a different, and at least partially irrelevant, set of pitches lying under a string tuned, say, to B. More specifically, the second string will produce a transposition of the scale of the first, and the two scales are likely be to some degree foreign to one another. On a guitar with its six open strings tuned to five or six different pitches, the confusion is compounded. This problem may not be insurmountable, but it is a challenge.

David Canright took the bull by the horns when he fretted the justly-tuned guitar shown above. His approach was to include a great many frets crossing the fingerboard, providing most of the pitches one might need on any string. The results, he feels, were mixed: the pitches are indeed available, and can sound clearly even when the frets seem too close together to place a finger between. But the profusion of frets and their uneven spacing increases the difficulty of playing to a degree that can be inhibiting. In an article which appeared in 1/1, David talks about the pros and cons, gives details of his chosen tuning, and talks a bit about the construction process (1/1, Volume II #2, Spring 1986, available from 535 Stevenson St., San Francisco, CA 94103).

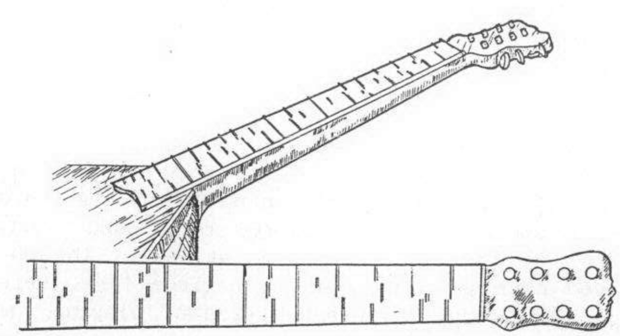


David Canright's justly-fretted guitar.

Photo by Henry S. Rosenthal. Reprinted with permission of 1/1, the Quarterly Journal of the Just Intonation Network.

Another approach to the problems of fretting for just intonations is the use of fretlets. If each differently-tuned open string calls for a different fretting pattern in order to bring the instrument as a whole in tune with itself, you can abandon the idea that all frets must completely cross the fingerboard and pass under all strings. Short frets can be installed which lie under just one or two or three of the strings, making it possible to have different fretting patterns under different strings. This approach can indeed produce a well-tuned and reasonably playable instrument (though it is still a bit more difficult than one with the uniformity of equal divisions). Its major drawback is that to keep the overall fretting pattern reasonably simple and playable, the instrument may have to be dedicated to a single key and modes thereof, making playing in other keys awkward or impossible.

A similar effect can be achieved by the use of non-linear frets. Frets which are calculatedly bent or made to lie in an undulating pattern across the fretboard can contact different strings at different points along their length, in effect creating different fret spacings for the different



strings. An example of this can be seen in the two wiggly frets on the Aquavina made by Jacques Dudon and pictured in EMI's last issue (Feb. 1988, Vol. III #5).

Another approach is the use of movable frets. Many early European instruments, lutes included, had movable frets in the form of wire or gut strings tied around the neck. They could readily be slid a short distance up or down the neck as the need arose. Many contemporary instruments, particularly in India, also have movable frets. Such frets do cross under all the strings at the same point, and the problems attendant thereto remain, but the flexibility of the system is still valuable. On the other hand, the inconvenience of shifting frets around for compositions in different tonalities can be a burden.

Several builders have experimented with movable fretlets. In the 1820s an Englishman named General T. Perronet Thompson built what he called an Enharmonic Guitar, with removable staple-shaped frets made to fit in pairs of holes drilled all along the neck. In the 1850s Rene Lacote, a Frenchman, devised an arrangement in which fretlets were mounted small blocks of ebony, which could be moved in grooves set into the fingerboard. Once in the desired position they were made fast by slivers of cork.

More recently Edward Clemenco of Marin County, California, made a stainless steel banjo with fretlets which move in grooves under the strings. Stuart Quimby in Barrytown, NY, has worked on a system for guitar in which fretlets are mounted on square pegs made to seat in square holes in the neck, producing fret spacings adjustable in increments of 1/32 of an inch. The German builder Walter J. Vogt uses a system in which a hundred and ten individual tiny, slightly curved fretlets sit in as many slots in the neck, each slot about a half inch long. Within this range the frets are movable. Vogt uses the system as a means of achieving the greatest possible precision in realizing twelve tone equal temperament, and he painstakingly custom-tunes each fretlet of each guitar to which it is applied. The curvature of the fretlets (they are shaped like parentheses, with the convex side toward the bridge) is designed to offset pitch rise from any increase in tension on the string arising from inadvertent lateral displacement during fingering.

The great advantage of these movable fretlets systems is, of course, their complete flexibility. The major drawback is inconvenience. Re-setting for any new tuning is a very slow task.

Another means for achieving intonational freedom in fretted instruments -- this one designed with convenience and speed in mind -- is the use of interchangeable fingerboards. A single instrument can play in any number of unrelated scale systems if the player can easily remove a fingerboard fretted to one tuning and replace it with another tuned differently. The challenge in creating such an instrument is finding some means of quickly and securely attaching and releasing the fingerboards. The leader in this area was Tom Stone. Some years ago he devised and patented a system for magnetically-attached fingerboards, and marketed it through his Novatone Company until recently. Microtonal musician Mark Rankin has now received a license from the apparently moribund Novatone company to manufacture the magnetic interchangeable fretboards. For under $200 he is offering Do-It-Yourself kits for adapting existing instruments. Each kit contains all the materials needed for four interchangeable fretboards. With frets in the proper positions, any number of non-western scales as well as historical western scales are suddenly available; or you can create your own experimental scales.

Mr. Rankin has recently collaborated with a computer programmer and is also offering accurate, actual-sized fretboard templates for any octave-repeating scale in any key for any open string tuning of any length or fretboard width. The program that generates the templates is called the Universal Microtonal Fretboard Printing Program. Such templates could also be of value to players of instruments in the fretless violin family, to help visualize fingering positions for exotic scales.

Mark Rankin leads a travelling life, and dispenses this radical technology from his rusty 1970 Chevy Nova. He does have a mailing address from which his mail is forwarded. For more information write to:

Mark Rankin
Franklin City,
c/o Greenbackville, VA 23356

One more approach to intonational freedom that should be mentioned here is fretlessness. Of course, most contemporary bowed string instruments have been fretless all along, and have enjoyed the freedom of intonation that some frustrated fret players seek (as well as greater difficulty of technique and intonation). Fretlessness works with bowed strings because the bow imparts continuing energy to the string, sustaining the sound as long as the player wishes. A plucked string pinched between finger and fretless fingerboard, on the other hand, is muffled by the fleshy fingertip and has little sustain, as with, for example, a pizzacato violin. In bass instruments, the mass of the string is sufficient to overcome this muffling effect to a degree; thus string basses are routinely played by plucking without anyone complaining about sustain. But on a mid-size instrument like a guitar, the fretless tone is closer to the pizzacato violin than either fretted guitar or string bass; and the lack of sustain is a major a drawback.

A perfectly effective solution to the sustain problem is to play with a sliding steel, Hawaiian guitar-style. Indeed, that approach has become very popular with microtonalists. Another solution, pioneered by Randy Roos some years ago with his Fretless Holland Sustain Guitar, is in effect to apply an E-bow-like device to a fretless electric guitar. The signal from the vibrating strings is sent from an amplifier back to an electro-magnet suspended above the strings, creating a feedback loop that perpetuates the vibration. The result is a fretless electric guitar with all the sustain the player could want.

COMMENTS FROM IVOR DARREG

As indicated in the article above, Ivor Darreg was one of the first among contemporary builders to begin refretting for microtonal scales. For that reason we made sure to send the article to him for his reactions prior to publication. Here, less some material dealing with other matters, is his response (complete with one of his many personalized letterheads).

National Society for the Decriminalization of Microtones

Wenzdi 18 Novembur 1987

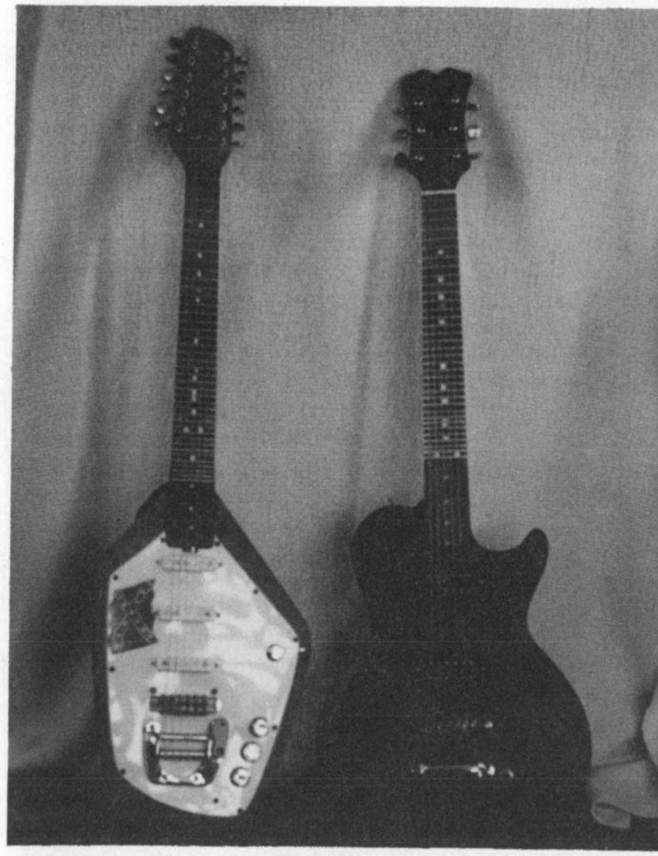
Greetings**

October already! I don't know where the time went. Must have been eaten up by the Clock-roaches.

Regarding your comments on just intonation guitars: I suspect a subconscious desire on the part of many people to try just, since many people use "open tunings" and will tune a just major chord on the open strings despite the twelve-tone frets being there. With just intonation and certain temperaments, notably 22 and 34, if the customary open-string tuning E A D G B E is followed, and if a just major third (or the best major third in those temperaments) is put between G and B, then the two E's will be out of tune! That is to say, in tuning systems where the tiny interval called a comma exists, the the standard tuning leads to problems. Ervin Wilson of LA, who got me started refretting in the first place, tried variant tunings to tame the 22 tone system, and I use one of his. Personally, I evade the just-intonation-fret problems by using steel guitars and the Megalyra family [both of which use a sliding steel instead of frets to select pitches] for just intonation, having only painted fret-lines. Comma-placed frets, which are necessary for the second degree of a major scale, are very close together, and come out to 1/55 octave, which is too close for most people's fingers. In just intonation, the false flat fifth between 9:8 and 5:3, is very disagreeable, so a second degree a comma lower, viz. 10:9, must be provided, and then you get that too-close fretting and lots of dissatisfied players.

For guitars, the 31-tone temperament, which is meantone for all practical purposes -- I mean who EVER is going to be able to fret 0.7 of a cent on a guitar? -- gets rid of the comma and its problems. There are instruments precise enough to experiment with and perform with commas 81:80, but the guitar just isn't suitable for that, and I think I have the right to assert this after 24 years' experience with it.

A news item to file away: Richard Koerner in Westport Connecticut has about completed a special guitar having three necks for 19, 22, and 31-tone, joined at the top as well as the bottom, sharing one body -- he sent me pictures the other day.



Guitars refretted by Buzz Kimball
to 31 & 34 tone equal temperament.

If you want to get into the History of Refretting sometime, I have a few leads: General Perronet Thompson, about 150 years ago in England, constructed an Enharmonic Guitar for just intonation with some frets pull-out-and-plug-in so that comma shifts could be made that way. He also had a three-keyboard Enharmonic pipe organ. Julian Carrillo in Mexico had quarter- and eighth-tone fretted instruments and composed for them. Augusto Novarro, also in Mexico, refretted to many scales and published a book on this in Spanish -- very rare and hard to get. Both these endeavors took place around the 1920s.

It is my understanding that two of Carrillo's fretted instruments were even played at a special orchestra concert with Stokowski conducting. That really must have infuriated the Musical Establishment!

I suppose I better add a footnote for you to file away if somebody ever raises the question: Five years ago I asked some people about the various guitar synthesizers -- would they or would they not follow a refretted guitar in a new scale? Craig Anderton wrote me that some of them will. Others will not because they are tied to 12-tone equal temperament at the factory by Quantizing Circuits built into the electronic parts. So any user of refretted guitars that wants to hook up to a synthesizer had better investigate first before buying the wrong unit!

Ivor Darreg

RETROFRETTING FOR NON-TWELVE SCALES
By Buzz Kimball

Refretting a stringed instrument is one of the easier ways of getting into experimenting with a non-standard scale. In this way the curious, or those bored with the same old tired twelve tone cliches, can make an end run and neatly evade the built in sonic limitations of the typical factory product.

TOOLS AND MATERIALS

A few special tools are required, the most important being a kerf saw (a kerf is a slot in a fingerboard which holds the tang of a fret). But people in hardware stores will look at the ceiling and people in music stores will try to push you out the back door and beat you up if you ask for a fret saw. Some guitar tool catalogs list fret saws. But I have usually used a jewelers saw which can be found in larger hardware stores. Pick up some extra medium size blades, as they don't last long. A good ten or twelve inch mill file (which is rare) or a large sharpening stone is good for leveling the frets after they are in place. A Thomas-Ginex fret refinishing kit, or equivalent, is helpful if available but not necessary. Also, a small ball peen or tack hammer is preferable over a carpenter's hammer.

In modern instruments individual frets are cut from lengths of fretwire, which can be bought by the foot. Getting fretwire can be a trying experience when you try to purchase it. Most music stores don't carry it but most places will order it for you. Prices will vary greatly depending on the fickle of the merchant you ask. I have seen prices from fifty cents an inch to fifty cents a foot. Enough said. Expect to pay $1.50 a foot, which is five or so frets, and up to $10.00 for a bag of twenty-four individual frets. Don't forget that for a microtonal scale you will need two for seventeen through twenty-four and three for thirty-one and beyond. The standard procedure used to be to purchase fretwire by the roll, and you will have to pay a markup to those who have to cut the roll up into pieces to sell smaller amounts, which causes considerable waste. Different manufacturers have different ways of indicating fret wire dimensions, but basically, there are three sizes of fret wire: small, medium and large. Large is definitely a no-no with a microtonal tuning: there is just not enough room in the high registers, where frets are close together (figure 1). The depth of the tang is important and shouldn't be greater than the thickness of a fingerboard. I messed up a perfectly good Fender Stratocaster but managed to save it and learned how to replace fingerboards at the same time.

X SECTION OF A FRET

FIG 1

In addition to hardware stores and music stores, fret wire and most of the tools described above are available through luthiers' supply houses. So are various more specialized materials for fret work. Two prominent suppliers are Luthier's Mercantile (PO Box 774, Healdsburg, CA 95448), and Stewart-MacDonald (21 N. Shafer St., Athens, OH 45701).

ALTERNATIVE EQUAL TEMPERAMENTS

Dozens of equal temperament tuning systems have been tried in addition to the standard twelve divisions per octave, and any particular number is fair game. Nineteen, twenty-two, and thirty-one divisions per octave are some that have found favor. Fretting tables for several of these are given at the end of this article. For a twenty-five or twenty-six inch string length instrument (full sized guitar) the nineteen and twenty-two equal division systems are the easiest to handle. Thirty-one is possible but it requires a great deal of patience. Seventeen and thirty-four will also work; they are left field territory. Quartertones (twenty-four equal) will need very special new timbres for their beauty to emerge -- in my personal opinion, there has been considerable

More guitars refretted by Buzz Kimball: 19, 22, 31, fretless, 17, 34, 18, 41, 43, & 24 tone equal temperaments.

amounts of real bad quartertone music made on conventional instruments, but there is an occasional gem.

CHOOSING AN INSTRUMENT FOR REFRETTING

Some types of fingerboards make the job of refretting more difficult and should if possible be avoided in choosing an instrument for refretting. Contrary to popular opinion, most guitar factories do use glue to hold the frets in place, making it more difficult to remove them without damaging the fingerboard. But if you shop carefully and pick a good instrument with a hardwood fingerboard, you will have less problem. Incidentally, you may be able to purchase an instrument with a high or unruly action at a good discount, since you will be reworking the action anyway. I have run into a few guitars which had fingerboards made out of what seemed to be pressed wood, and the surface was really just sprayed on. Caveat emptor. Also, avoid guitars with plastic binding around the edge of the fingerboard. If need be, however, the necks of such guitars can be reshaped and refinished without the binding.

REMOVING THE OLD FRETS AND PREPARING FOR THE NEW

Assuming you have selected an instrument to work on, decided on a scale to refret to, and have a table for your string length, now is a good time to pull out the old frets (detwelvulation). Running a single edge razor or carpet knife between the metal and wood will reduce chipping. Prying frets without marring the fingerboard is impossible, but it helps later if you avoid gouges. A fence pliers works well after the end of a fret has been pried up.

After all the frets have been pulled out it is time for putty and sand paper. Fill all the old fret slots with wood dough or plastic wood. After it has hardened but not totally dried -- sand. This gives a new smooth fingerboard and works wood particles into the wood dough, giving enough color to hide the old slots. If a better color match is desired, you'll find that stains don't work well, nor do paints; but liquid shoe dye does. A real perfectionist, however, will want to simply replace the fingerboard before refretting, rather than trying to conceal old fret lines.

Mark out the new kerfs, in accordance with your chosen intonation system and the appropriate fret table. To do this, measure out and mark on both sides of the fingerboard, then draw lines across. If the resulting lines appear slanted, it might be a good idea to start again. (There is a certain amount of tolerance, of course). With a kerf or jewelers saw, cut new kerfs. Go slow, as any wobble will make new kerfs wide and sloppy on the edges, and the only solution to that is a lot of glue.

Once in a while a new kerf will be extremely close to an old kerf, in which case one has to decide whether to shift the position of the fret or use lots of glue. Even if there is a small space between the new kerf and an old one there may be a problem: sometimes a strip of fingerboard a millimeter wide or more between two kerfs will break away when the tang of the fret is inserted. Five minute epoxy is a good cure.

After the kerfs are cut, you may want to bevel the top edges of the slots very slightly with a small triangular file. The allows the fret to seat properly even with the slight curvature found on many frets where top meets tang. It also makes it less likely that the fingerboard will splinter should the fret ever have to be removed in the future.

PUTTING IN THE NEW FRETS

Putting in new frets is without a doubt the most difficult phase. Standard practice is to cut and shape the fret first and then place it in the kerf. Personally, I have never had any luck with that -- possibly due to a lack of patience -- always one or three popping up at the edges. So I found it just as easy to epoxy (twelve hour) the entire fret in, instead of trying to glue down a few loose ends. The easiest and most uniform method I've found is to cut a fret with an extra half inch or so, and then hammer the tang of the fret into the kerf, allowing some of the fret to protrude on either side. Generally, I clamp the frets down to insure that there will still be a good tight fit after the glue dries. Putting a board on either side and then clamping ensures an even distribution of pressure (figure 2). A slow drying epoxy is required, which will allow adequate time to position a group of frets before applying pressure. Inserting six to twelve frets each evening means fewer clamps are needed.

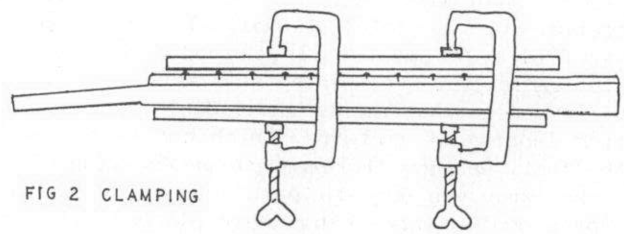


FIG 2 CLAMPING

Quick drying epoxy is better for ex post facto individual fret repairs, since it allows you to replace an unsatisfactorily seated fret and continue work on the instrument in the same evening. After the glue has dried I use the jewelers saw to trim off the excess fret. Then the edges of the fret may be rounded and shaped with a file or dremel tool.

LEVELING AND ADJUSTING

At this point the microtonal refretter ought to break from tradition and level the frets. As the phrase implies, bring the fret height down to a uniform level. Leveling the frets decreases the amount of fooling around later and is the only way of ensuring a decent low string action instrument. I put a file or sharpening stone on the face of the frets and file until a level plane exists along the entire surface. Don't overdo it at this point, since the neck is not yet under tension. Obviously, string tension will later change the topology of the neck. When the leveling is done the hammer marks on the frets will generally be gone and a modest amount of metal particle fallout will indicate how much metal has been removed.

After the frets have been leveled and rounded the old strings can be put back on. If a fret polishing kit is available then a modest amount of leveling done under string tension will be helpful (figure 3). Otherwise, a piece of black garnet

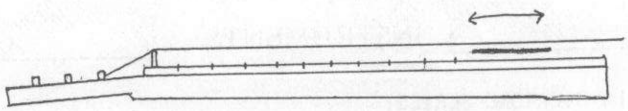


FIG 3 POLISHING FRETS WITH NECK UNDER TENSION

paper and a thin rectangle of wood can be used to polish the frets. The strings will have to be blocked up off the neck, so reduce them from standard tension, as needed. After this there will be sharp edges running the length of the fret, and you will sometimes feel them as your finger slides up a string. These need to be rounded. A piece of garnet paper wrapped around a dowel or cigarette light will take care of it.

At this point the lowest string height is adjusted. This is a matter of trial and error as the bridge and truss rod interact. With larger numbers of frets per octave the tolerance and the string height will have to be slightly higher than they would be on to a twelve tone instrument. It is a good idea to test each fret position under each string all the way up to the highest note. This can be time consuming on a 31 tone refretting. A small flat Swiss file will help readjust the height of an individual fret or frets under a particular string. Sometimes the small file takes care of it, and sometimes the frets need to be polished again. It can be annoying to pick up a refretted instrument and run into a fret buzz that wasn't there last week.

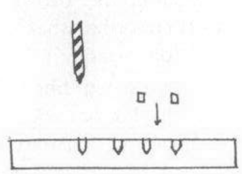
My experience is that a guitar will grow and shrink with the temperature and humidity, so a "final" adjustment can be done in six months or so. Of course, the new sounds can still be enjoyed in the meantime.

REPLACING A FINGERBOARD, AND INLAYING

Replacing a fingerboard is not as bad as it sounds, but it's worth avoiding if possible. The old fingerboard is removed with a chisel, which is not difficult because of the slots already cut in it. Then a piece of hard wood of similar thickness is cut, shaped and glued into place. For a curved fingerboard, six or eight clamps are required. And the grains of wood should run lengthwise, otherwise bending is difficult and the frets will not hold.

Inlaying is not difficult either. Drill, plug and sand. On a fretless instrument dowel slices can be glued (Elmer's) into holes drilled in the fingerboard (figure 4). Sometimes small drill holes, around one-eighth inch, can simply be filled with wood putty. I never put pearl inlays into the refretted guitars since I couldn't decide where they should go. I once used a hole punch on gummed labels to make some stick-on dots for a fretless instrument, and experimented with many different scales until I was ready to inlay and dedicate the instrument to specific scales.

FIG 4 DRILL, PLUG & SAND



I cannot emphasize enough the importance of experimenting. Especially when you are working on an instrument you are emotionally attached to, placing two or three practice frets in a piece of scrap wood, or drilling holes and inserting dowels, ensures the correct selection of saw width or drill size. While refretting doesn't require a lot of manual dexterity, it is time intensive and patience is a requirement. Having a book on guitar repair will help, but remember that a microtonal fretting does change the tolerances and the game somewhat. Studying an existing instrument will help clarify small details. Final fret shape is a matter personal preference, but sharp edges do have a habit of making themselves known.

Being realistic, my descriptions are brief. And in any modification/building process you ought to take any and all advice from any source with a certain amount of caution. The processes are not absolute and some may not be of importance for you. I have only described a process for an experimenter, outside of any factory, to modify an existing stringed instrument and insure that it will be playable for a long time.

The fretting charts given here are for the more important equal tempered scales that are within the limits of practicality for guitar or bass. Just intonation has not been considered and, in my opinion, any well developed just scale is not physically feasible on a fretted instrument. However, almost any fretted instrument is adequate for experimenting with just intervals, provided you use a steel.

Each chart is given for a 1 meter (1000mm) string length. To apply these tables to your instrument you will need to ascertain the string length of your instrument. This can be done by measuring from the nut to the original octave kerf (the theoretical half-way point) and doubling. This approach should produce a better result than nut to bridge, assuming the original frets were producing accurate intonation. The reason is that in practice the frets must be slightly displaced from their mathematically correct position to allow for pitch change resulting from the slight increase in tension when the string is pressed down; the half-way measurement takes advantage of the original fretwork's correction factor.

To find fret locations, convert to meters and multiply values in the table by your string length.

Example -- Finding the location of the first fret in 19 equal, for a string length of 623 mm: The chart indicates that for a string length of 1000 mm, the first fret would be at a distance of 35.82 mm, or .3582 m, from the nut. For a string length of 623 mm, or .623 m, the first fret would be at distance of

.623 x .3582 = .223 m, or 223 mm.
from the nut.

(Fretting charts are at the bottom left on page 14.)

To calculate a table for a scale not given use the algorithm:

Where l = string length
n = number of equal divisions per octave
d = number of the scale degree whose location is desired, assuming the first degree is given the number 0
p = the position of the fret, given as the distance from the nut

$$p = \text{absolute value} \left\{ \left[L/(\sqrt[n]{2})^{d} \right] - L \right\}$$

To find fret locations for just intervals:

Where x/y is the desired frequency ratio between the open string and the fretted pitch
l = string length
p = position of the fret

$$p = \text{absolute value} \left\{ \left[(x/l)\, y \right] - l \right\}$$

FRETTING CHARTS

The four sets of figures represent 19, 22, 24 and 31 tone ET. For each group the left column gives the scale degrees. The middle column gives fret locations for the 1st octave in distance from the nut, for a one meter string length. The right column covers the second octave. The number at the top of each column is the multiplication factor between successive scale degrees.

1.037155

0	0.00	500.00
1	35.82	517.91
2	70.36	535.18
3	103.67	551.83
4	135.78	567.89
5	166.74	583.37
6	196.59	598.29
7	225.37	612.69
8	253.12	626.56
9	279.88	639.94
10	305.67	652.84
11	330.55	665.27
12	354.53	677.27
13	377.65	688.83
14	399.95	699.97
15	421.44	710.72
16	442.17	721.09
17	462.15	731.08
18	481.42	740.71
19	500.00	750.00

1.032008

0	0.00	500.00
1	31.02	515.51
2	61.07	530.53
3	90.19	545.10
4	118.41	559.20
5	145.75	572.88
6	172.25	586.12
7	197.92	598.96
8	222.80	611.40
9	246.90	623.45
10	270.26	635.13
11	292.89	646.45
12	314.82	657.41
13	336.08	668.04
14	356.67	678.33
15	376.62	688.31
16	395.96	697.98
17	414.69	707.35
18	432.84	716.42
19	450.43	725.22
20	467.48	733.74
21	484.00	742.00
22	500.00	750.00

1.029302

0	0.00	500.00
1	28.47	514.23
2	56.13	528.06
3	83.00	541.50
4	109.10	554.55
5	134.46	567.23
6	159.10	579.55
7	183.04	591.52
8	206.30	603.15
9	228.89	614.45
10	250.85	625.42
11	272.17	636.09
12	292.89	646.45
13	313.02	656.51
14	332.58	666.29
15	351.58	675.79
16	370.04	685.02
17	387.97	693.99
18	405.40	702.70
19	422.32	711.16
20	438.77	719.38
21	454.75	727.37
22	470.27	735.13
23	485.35	742.67
24	500.00	750.00

1.022611

0	0.00	500.00
1	22.11	511.06
2	43.73	521.87
3	64.88	532.44
4	85.56	542.78
5	105.78	552.89
6	125.55	562.77
7	144.88	572.44
8	163.79	581.90
9	182.28	591.14
10	200.36	600.18
11	218.04	609.02
12	235.33	617.67
13	252.24	626.12
14	268.78	634.39
15	284.94	642.47
16	300.75	650.38
17	316.22	658.11
18	331.34	665.67
19	346.12	673.06
20	360.58	680.29
21	374.72	687.36
22	388.54	694.27
23	402.06	701.03
24	415.28	707.64
25	428.21	714.11
26	440.86	720.43
27	453.22	726.61
28	465.31	732.66
29	477.13	738.57
30	488.69	744.35
31	500.00	750.00

INSTRUMENTS

THE OVERTONE SERIES?
The Harmonic Series as a Special Case, and Some Thoughts About Instruments with Inharmonic Overtone Spectra

Article by Bart Hopkin

With the increased interest in exploration of just intonation systems and their rational basis, the overtone series has played a prominent role in a lot of discussion and theorizing lately. The intervals of the series are usually regarded as natural and pure, in contrast to the contrived intervals of equal temperament. Accordingly, it is often cited in advocating various existing or proposed musical systems, or in efforts to understand psycho-musical phenomena.

And so, out of my own perverse inclination to be irritating, I make this observation: our familiar overtone series isn't really all that natural. As an acoustic phenomenon it appears in specific circumstances which occur relatively rarely in nature. Any number of other series could claim comparable validity.

This article will be divided into two main parts. The first is a general look at some of the overtone patterns to be found, latent or manifest, in several different instrument types. Having thus highlighted the existence of nonharmonic patterns in many instruments, the second part will consider how the ear responds to irregular series, and how such series can function musically. Additionally, the separate box at right provides some background information on instrumental overtone spectra for anyone not already familiar with the subject.

Needless to say, the purpose of this discussion is not to discredit the accepted overtone series, or instruments and musical systems derived from it. For centuries people have consistently been drawn to its relationships, and the beauty of existing music and instruments based in it speaks for itself. This article merely draws attention to some other possibilities, especially as they relate to musical instruments.

OVERTONE SPECTRA, HARMONIC AND OTHERWISE, IN EXISTING OR POSSIBLE INSTRUMENTS

One of the primary ways in which the standard overtone series appears in our music is through the instruments we use. While many familiar instruments don't adhere to the pattern, most wind and string instruments reproduce the harmonic series, in some mix or other, in their overtone spectra. With most of these, the tones of the series can be isolated and played in sequence, producing the series in scale form. Thus the series seems to be built into the instruments.

But instruments which adhere to this pattern do not do so because of some irresistible force of nature. They do so because instrument builders go to great ends to arrange for them to do so.

Let's look at vibrating strings. To create a stretched string whose modes of vibration conform

to the accepted relationships of the harmonic series, several conditions must be met:

First, the string must be of uniform mass and diameter over its vibrating length. If it is more massive, say, at one end, the nodes and loops that define the sub-vibrations within the fundamental vibration will appear at irregular intervals, producing inharmonic overtones. As an example of the musical effect of unevenness, irregularities occur in nylon guitar strings which have begun to wear and stretch. Though the distortion in the form of the string may be tiny, the acoustic effect can be heard.

Secondly, the string must theoretically be of infinite flexibility, for rigidity in the string introduces distortions in the vibrating pattern, causing it to behave more like a rod fixed at both ends. In practice this consideration is not as devastating as it might at first appear, since the effects of a small amount of rigidity are negligible. But it does come into play in heavy piano strings, making the upper partials sharp and leading piano tuners to devise compensatory strategies. It is also the reason why bass strings are usually overwound with metal wire (overwinding allows for greater mass with a minimum increase in rigidity).

Thirdly, one must consider the shape of the string in cross section. Most strings used on musical instruments are round. Other shapes may produce harmonic overtones, but they introduce complicating factors in the direction of the impulse given to the string, and to a lesser extent in the effects of wind resistance and torsional vibration.

Fourthly, the string must be free of obstruction over its vibrating length, and not coupled to any resonating bodies having strong frequency biases which could throw things off.

Some of these criteria are rarely met in nature. All of them being met simultaneously is a special situation indeed. Much more "natural", in the sense of being less a product of human contrivance, would be a situation in which the conditions are not met, and the vibrating string produces its own idiosyncratic overtone mix.

A different set of prerequisites are involved in producing the standard overtone series in wind instruments. With aerophones using enclosed chambers (as do most of our standard wind instruments), the primary factor is the shape of the chamber. Globular chambers scarcely produce audible overtones. Most other possible shapes produce irregular overtone series. Those that do produce the accepted series are a group consisting mostly of uniformly cylindrical or conical tubes or carefully chosen combinations thereof (for the purposes of this discussion, the possible existence of a bell at the end may be discounted in describing these shapes). Of all possible shapes for air chambers, these constitute a rather specialized minority -- although it should be noted that approximations of them do occur naturally. We design our wind instruments to utilize these shapes, or acceptable approximations to them, in order to preserve the integrity of the preferred series. So once again we have a situation where nature does not dictate the overtone series to us;

SOME BACKGROUND ON THE OVERTONE SERIES AND ITS APPEARANCE IN MUSICAL INSTRUMENTS

For those who are not already familiar with this information: In the abstract, the overtone series is a set of mathematical relationships between rates of vibration. Those relationship are simple. Beginning with any root frequency X, the frequencies of the series are equal to X, 2X, 3X, 4X, etcetera. Translated into musical terms this amounts to the root pitch (the pitch associated with frequency X), followed by an ascending series of untempered pitches in progressively smaller intervals: the octave above, the twelfth, 2 octaves... in short, some transposition of the pattern C, c, g, c', e', g', b-flat' (very flat), c", d", e"... and onwards and upwards.

This pattern manifests itself in our music in many ways. For instance, it provides the most important constituents of the tone quality of most wind and string instruments. What the ear normally hears as a single instrumental tone is actually, in most cases, a composite of several frequencies. For most winds and strings the mix of frequencies in that composite tone is based primarily on the relationships in the lower part of the overtone series. Such overtones are called "harmonic overtones" or simply "harmonics." Any overtones present which do not conform to the series are described as "inharmonic."

In the case of strings, the blend of tones arises because the vibration of the entire string contains within it sub-vibrations. Simultaneous with the larger vibration, the string divides into smaller vibrating sections, with adjacent sections moving in opposite directions. The frequencies of these sub-vibrations, for physical reasons, correspond (ideally) to multiples of the frequency of the whole string, thus reproducing the harmonic overtone series. Vibrating air columns behave similarly, containing fractionally smaller vibrations within the larger. In most winds and strings, these smaller vibrations can be isolated and played separately, producing the tones of the overtones series in melodic succession. The series thus seems to be naturally built into the instruments. This article suggests, however, that other overtone series --inharmonic series -- can and do also arise, and may have their own special sort of musical merit.

rather, we go to considerable trouble to select one particular series out of many possible ones.

Winds and strings aside, most other vibrating systems that are employed in musical instruments do not reproduce the accepted overtone series at all. In most cases where such instruments have been accepted into the musical mainstream, the partials are quiet enough that they remain unobtrusive and can easily be ignored. But in other cases, people simply accept and enjoy the overtones as they are, as part of a peculiar instrumental timbre.

In the category of instruments possessing unobtrusive inharmonic overtones, we can take as an example the vibrating bar instruments such as vibraphones and marimbas. Theoretically these instruments will have their first overtone at 2.756 times the fundamental frequency; the next at 5.404.[1] However, this assumes uniform rectangular dimensions (no scalloping underneath for tuning). In practice, between such considerations of shape and the possibility of irregularities in the rigidity or density of the material itself, the placement of these overtones is less predictable. It often happens, however, that the partials have little musical effect anyway. Most of the overtones present in the bars are inhibited by the mounting system for the bar, which allows the fundamental to vibrate freely while damping other vibrations. Additionally, inharmonic overtones are suppressed by the resonator tubes below the bars (if such there be), which likewise enhance the fundamental and discriminate against inharmonics.

The best familiar example of the second category mentioned above -- instruments possessing a peculiar mix of prominent inharmonic overtones -- is bells. People have always found the timbre of carillon bells a source of fascination and delight, as well as an occasional source of aural confusion (which pitch is "the note?"). Bells which have not had their overtone recipe carefully tuned by the maker tend to have their own peculiar mixes of partials. With European carillons a tradition has grown up around the tuning of individual bells to produce a pleasing mix of pitches in the composite tone, and one particular overtone blend has become the desired norm. Prominent in it are tones approximately a minor third and a fifth above the tone the ear hears as the fundamental. That is quite out of line with the placement of harmonic overtones; but it happens to make for a grand and beautiful sound.

Here are just two more examples of rampant inharmonicity: For circular stretched membranes (a description which fits most existing membranophones), the theoretical frequencies of the second and third harmonics for the rotationally symmetric modes of vibration are 2.3 and 3.6 times the fundamental frequency. Additional partials for non-symmetric motions may also appear at 1.6 and 2.1 times the fundamental, and higher. For a rod fixed at one end, the theoretical first overtone will be found all the way up at 6.267 times the fundamental; the second at 17.55.

To sum all this up: Despite the fact that the harmonic overtone series is usually considered "natural", it is not a part of most acoustic systems. Among musical instruments, some produce a harmonic series because considerable effort has been expended to allow them to do so; some produce some other overtone series but have all but the fundamental suppressed for musical purposes; and some produce a different series which we happily hear and accept.

SOME MUSICAL EFFECTS AND IMPLICATIONS OF INHARMONIC OVERTONE SERIES

As we have seen, the ear accepts many timbres with inharmonic overtone spectra as fully musical sounds. In fact, many such timbres strike us as very appealing. Let's look a little more closely now at the way we respond to such sounds.

We should begin by acknowledging that inharmonic overtone blends are often somewhat unlovely, occasionally disturbing or irritating. After all, most of the world's unwanted noise falls in this category. The sounds that seem noisiest are generally those possessing a mess of disorganized partials; too many to make sense of. Because the tonal content of such sounds is confused and inconsistent, we don't hear them as having definite pitch. It would be hard to read a meaningful overtone series, conventional or otherwise, into such confused sounds.

With sounds containing fewer conflicting partials, the ear perceives what could be called a more musical quality. If the relationships are simple and clear enough, we may instinctively hear the tone as having a single defined pitch. How do we decide which of the many partials to hear as **the** pitch? The answer to this question is rather ambiguous.

Whether for physical reasons, some inborn psycho-acoustic reason, or simply due to acculturation, our ears are amazingly adept at interpreting composite tones possessing harmonic overtones. We hear an array of tones appearing as a single sound; in an instantaneous, effortless and unconscious process we come to recognize one as the fundamental and the defining pitch, and hear the rest essentially as components of timbre. This is true even in cases when the relative prominence of the various overtones is skewed.

We bring no comparable facility to inharmonic overtone mixes. Our tendency in these cases -- again, in an assessment performed largely unconsciously -- seems to be to regard either the most prominent or the lowest sounding pitch as the defining note or the fundamental (though it may not be the fundamental in a physical sense). If two or more tones of comparable volume are crowded near the bottom, the composite is especially difficult to resolve. We have an easier time of it if the pitches down there are widely spaced. A lot of partials crowded up on top doesn't seem to confuse us much if we have clear reference points in the lower frequencies. Of course, in these ambiguous situations there is no right or wrong way of hearing the composite, except in so far as it helps if people agree in their interpretation.

An important practical consequence of all this

1) The figures for the frequencies of upper partials given for bars here and for other vibrating systems later in the article are taken from **Music, Physics and Engineering**, by Harry F. Olson (New York: Dover Publications, 1967), pages 74-84.

is that timbres rich in inharmonic partials, while they may be appealing or intriguing, can be musically confusing. The ear may fail to settle on a single partial as the main pitch, or we may find our sense of the pitch shifting from one partial to another as we listen.

To my taste, some of the most enjoyable inharmonic timbres are those near the borderline, where one's sense of which pitch to hear as the fundamental can be altered by a mental trick of shifting perception. A simple melody played on an instrument of such timbre can be enchanting. But as we move toward increasingly complex nonharmonic timbres, chances increase that the listener will simply get lost in a confusing array of overtones. If that happens, the harmonic and melodic meaning of the music is undone.

When one nears the borderline of timbral resolvability, an important effect comes into play. A tone that is comprehensible in isolation may become incomprehensible when surrounded by other sounds. A melody that makes sense alone may lose its meaning and disintegrate into pitchless jangle when accompanied.

There are many familiar percussion instruments that are near that borderline, but which do still possess recognizable pitch. Many composers and arrangers tend to use such instruments in a manner better suited to pitchless instruments -- playing, for example, rhythmic accents or repeating metric structures on a clearly-pitched triangle or cowbell without regard their pitch or the harmonic context, just as one would an unpitched snare drum. But it happens that timbres of this sort work wonderfully as the stuff of melody and scales. Using them melodically forces the listener to hear the sounds as tonally meaningful, at the same time that it provides, through the horizontal dimension, a handle on what otherwise might be a disorienting set of overtone relationships. The result can be fresh and intriguing.

I have found that relatively simple timbres, having a smallish number of distinct, fairly prominent partials arrayed in unexpected relationships, are often most appealing. They are also relatively easy to come by, because many easily fabricated metallic idiophonic materials possess these properties.

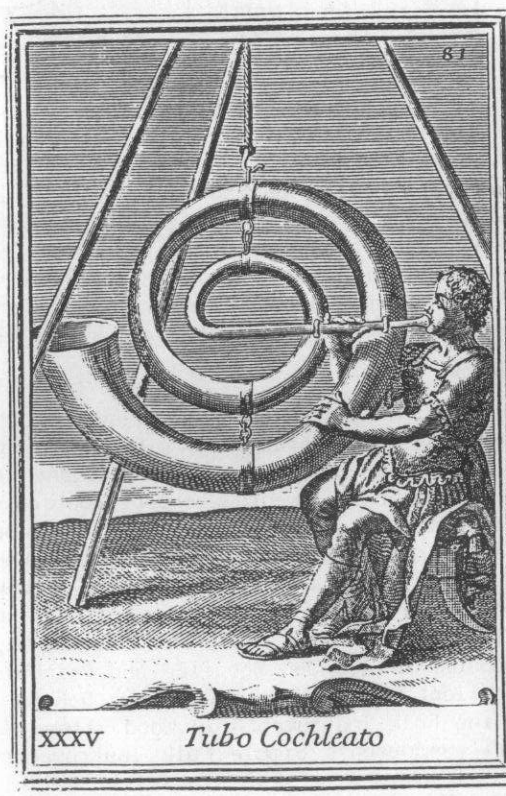
We have been talking about the timbral effects of inharmonic overtones. We should observe now that such timbral considerations have harmonic implications as well. (In fact, there is a point at which the delineation between timbre and harmony becomes indistinct.)

The standard harmonic overtone series has given rise to a world of tonal harmony which, in its ideal form, is consistent with the relationships of that series. In like manner, other series can suggest their own approaches to harmony and to scale systems. If the pitch relationships inherent in the instruments' overtone spectra are reflected in the melodic and harmonic nature of the music being played on those instruments, the whole may have an admirable coherence. One of the great joys in life, it seems to me, is encountering some new and unfamiliar musical dialect, especially one that successfully creates its own internally consistent set of characteristics and conventions. One way that special musical idioms like that can arise is in following the harmonic implications of some peculiar acoustic system to their natural consequences.

If this sounds farfetched or contrived, I can add that it need not be done in a highly self-conscious way. It may simply be a matter of allowing an instrument to suggest musical material, rather than imposing pre-conceived systems upon it. Peculiar overtone patterns can take on harmonic meaning almost automatically if one is willing to listen to the special timbral constituents of, for example, junk metal. It can also happen in a very lovely way with the sort of oddly-shaped flute that overblows some unexpected tones. Such a flute may possess a very simple timbre (few audible overtones) but provide a highly idiosyncratic vocabulary of pitch relationships. An improvisation by a thoughtful improvisor on such an instrument -- consistent, as it must be, to its own harmonic rules ...but such strange rules! -- often turns out to be an unexpected delight.

BOWED IDIOPHONES DECLARED
THREAT TO NATIONAL SECURITY

Spokesmen for a prominent public interest watchdog group asserted in a news conference recently that the fabric of American society is being rent asunder by the increasing use of bowed idiophones among today's young people. Citing recent studies linking exposure to unorthodox musical instruments to undesirable tendencies, the speaker observed that "well intentioned but naive 'musicians' are unknowingly being used as the launching pad for a massive assault on the American way of life."



Engraving by Fillipo Bonanni, from Gabinetto Armonico, 1776 (Reprinted by Dover Publications, NY 1964.)

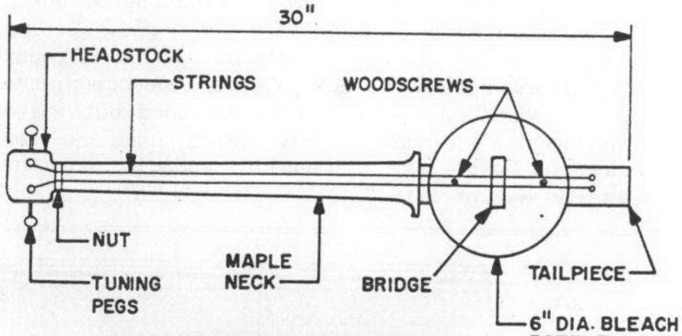
BOOKS & RECORDINGS

PERCUSSION, STRING AND WIND INSTRUMENTS, by Christopher Swartz

MUSIC FOR HOMEBUILT INSTRUMENTS, by Robert Hollis and Christopher Swartz

Book and LP available from Perimeter Records, PO Box 28882, Atlanta, GA 30358-0882.

The LP **Music for Homebuilt Instruments** contains ten pieces played entirely on about 30 instruments built by Christopher Swartz, a composer, performer and builder from Atlanta. The record jacket has photographs and descriptions of most of the instruments, and included with the album is a poster with some of the same photographs and some additional diagrams. (Also included is a nicely-drawn score for one of the pieces on the record.) More information on Swartz's instruments can be found in the book **Percussion, String and Wind Instruments**, sold separately from the LP. The book is about sixty photocopied pages long. For each of about twenty instruments or categories of instruments there is a descriptive text, followed by a page of photographs (not always clearly reproduced), and diagrams. More detailed mechanical drawings for many

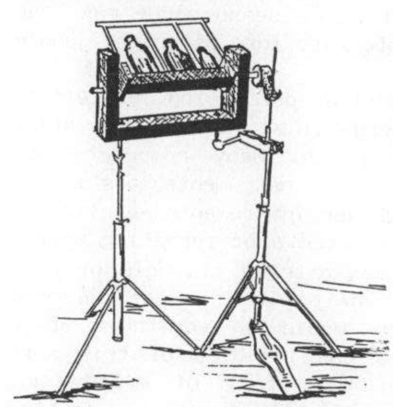


2 STRING GUITAR - TOP VIEW

of the instruments may be found in a final appendix. The book is designed for people interested in building the instruments shown or others like them, and it has most of the practical information one might wish for. Also included are generally useful things like techniques for hammering gongs from scrap metal, suggested materials for mallet heads, and such.

Swartz's instruments are primarily made of commonplace or scrap materials. They are nicely crafted, and possess a visual elegance even when the structural elements are construction grade, or even dumpster grade. Most of the instrument ideas are not radically new. Swartz's achievement lies in the creation and utilization of a diverse and satisfying homebuilt orchestra with ideas from a variety of sources. Among the sources he has made good use of are Jon Scoville and Reinhold Banek's excellent **Sound Designs** book, Dennis Waring's **Making Folk Instruments in Wood**, Ilene Hunter and Marilyn Judson's **Simple Folk Instruments to Make and Play**, and the work of Harry Partch. There are also a number of innovations in these instruments which appear to be Swartz's own contributions.

The Swartz instruments span several types. As mentioned above, he does a lot with hammered scrap metal gongs and cymbals. Several sets of them, mounted in various ways, sizzle up the orchestra. There are a number of electro-acoustic string instruments, including both lutes (meaning instruments with separate necks and soundboards) and zithers. For the acoustic strings there is a truly elegant 2-string guitar with a plastic bleach bottle resonator. There are the obligatory wood and conduit marimbas. Percussion racks with glass and metal idiophones are present. One of them, the Glass Rack (shown on the front cover), incorporates elements of Partch's Cloud Chamber Bowls and Mazda Marimba on a single frame. There are flutes, slide whistles and percussion aerophones of PVC.



VARIABLE PITCH BOTTLE RACK (drawing crudely rendered from the book's photocopy).

One of the most intriguing and original of Swartz's designs is his Variable Pitch Bottle Rack. It uses three glass bottles, graduated in size, partially filled with water. They are mounted on a rack which can be rotated by means of a foot pedal about one half turn, thereby tilting the bottles. As they tilt and the water within covers different portions of the glass, the pitch they produce when struck varies. The result is a glass glissando idiophone, capable of a continuous range of pitches.

For the recording of these instruments on the LP, Swartz is joined in performance by Robert Hollis. Their ten pieces display the instruments in various combinations, so that each piece is characterized by its own texture and timbre. It is in the distinctive timbral contrasts within and between the selections that the strength of the album lies.

The first side is dominated by motoric rhythms, with lots of ostinati and some rock-like sounds. The second side generally displays freer rhythms, and a sense of timbral exploration replaces the heavy pulse. The last piece, titled "Moonlight," stands out among the varied sonic landscapes that make up the album: against a back drop of spacious plucked string bass patterns, another bass and the two string guitar, both played with bows, stretch out in massive sliding tones -- a wonderfully evocative blend.

NOTICES/EVENTS

A subscriber to EMI recently wrote to ask about publications devoted to musical saw. We directed them to the one publication we were aware of, Sawing News of the World. Since then we have learned of another, newly launched musical saw newsletter called Musical Saw News. The price is $4/yr, from Musical Saw News, PO Box 84935, San Diego, CA, 92138-4935.

The Nature Sounds Society of Oakland, California, is planning a concert series for composers whose work is related to nature sounds, scheduled for this spring. Composers and others interested in participating should contact Paul Matzner at (415) 273-3884 or Wendy Reid at (415) 644-1685.

THE BUG - A Portable Electroacoustic Percussion Board. You can have a whole percussion orchestra at your fingertips in the space of only two square feet! The Bug, with its assortment of rods, nails, combs, springs and strings, will delight your ear and amaze your friends and fellow musicians. Almost any contact mic and amplification system may be used. The price for direct orders is $200.00 plus shipping. To order, write Tom Nunn, 3016-25th St., San Francisco, CA 94110, or call (415) 282-1562.

The New Music America Catalogs for 1981 and 1983 are now out of print. Is there anyone in EMI land who could lend me their copies or send a xerox? Tony Pizzo, RR #1 Box 64, Lunenburg, VT 05906.

Coming events:

April 29 & 30 8:00 pm at The Lab, 1805 Divisadero St., San Francisco, CA: Doug Carroll (cello and emulator), Ron Heglin (trombone & voice), James Russell (clarinets & sax), Tim Perkis (experimental electronics & computers), and Tom Nunn (crustacean, balloon drums & etc.) play improvised music. (415) 282-1562 for information.

May 14-May 21 in New York: Microfest, concerts of microtonal music and related events, sponsored by American Festival of Microtonal Music, publishers of Pitch. For more information write 211 W 108th St. #42, New York, NY 10025; or call (212) 864-2951.

Previously scheduled for May 1st, now moved to July 3rd at 2:00, 3016 25th St., San Francisco, CA: The New Instrments/New Music series continues with Jonathan Glasier, composer, instrument maker, and publisher of Interval Magazine. Jonathan will have just returned from Microfest in NY; he'll report on that event, and will also have with him a tubulong built by Erv Wilson in a nine-tone just scale. (415) 282-1562 for information.

STRING INSTRUMENT MAKERS' MEETING: The Guild of American Luthiers 11th National Convention / Exhibition will be held June 16-19 at the University of South Dakota in Vermillion, hosted by the Shrine to Music Museum. The convention will feature lectures, demonstrations, and exhibition of handmade instruments. Lectures include: Baroque, classic, and steel string guitar repair; strings; research techniques; and tropical hardwoods. Write for registration form. Guild of American Luthiers, 8222 South Park, Tacoma, WA 98408; (206) 472-7853.

CASSETTE TAPES FROM EMI: From the Pages of EMI Volume I is a 45 minute cassette featuring instruments that appeared in EMI during its first year of publication. Its successor, From the Pages of EMI Volume II, is a 60 minute cassette with music from EMI's second year. Each contains a full measure of odd, provocative, beautiful, funny and lively music. The cost is $6 apiece for subscrib-ers; $8.50 for non-subscribers, from Experimental Musical Instruments, Box 784, Nicasio, CA 94946.

THE SONIC ARTS GALLERY in San Diego will be showing an exhibit of tubulongs and related steel conduit instruments built by Erv Wilson, Glen Prior, Ivor Darreg and Jonathan Glasier; also shown will be the Dodecahedron, a metal percussion instrument comprised of the bottoms of 12 secretary chairs. The exhibit runs through the end of April, at 612 F, San Diego, CA 92101. Starting in June the Sonic Arts Gallery will present a show of unusual, quirky and offbeat electronics.

JUST INTONATION CALCULATOR
by Robert Rich

The Just Intonation Calculator is a shareware Hypercard stack for the Macintosh designed to take the tedium out of composing in JI, as well as provide a learning tool for those curious about the mathematics of just tuning systems. It performs a wide range of mathematical calculations based on ratios, as well as exponential and logarithmic conversions. Features include:

- Handles up to 48 notes per scale; scales need not be octave repeating.
- Calculates intervals for modulation in the scale relative to any new tonic (whether or not the new tonic appears in the scale.)
- Converts successive ratio scales to relative scales, and calculates successive ratios from relative scales.
- Calculations resulting in multiple octave intervals can be collapsed into single octave representations.
- Shows cents, DX7II and TX81Z tuning units for any ratio. The results of any ratio-related calculations can also be viewed in cents.
- Calculates approximate ratio intervals from cents, DX7II or TX81Z tuning units, with a user variable error margin. (More exact approximations generally result in larger numbered intervals.)
- Automatic reduction of fractions in all calculations.

Price: **$10.00** from: Soundscape Productions
P.O. Box 8891
Stanford, CA. 94309

Listed below are selected articles of potential interest to readers of **Experimental Musical Instruments** which have appeared recently in other publications.

PETE ENGLEHART METAL PERCUSSION by John Burks, in **Drums and Drumming** Vol. II # 1 (20085 Stevens Creek Blvd., Cupertino, CA 95041).

A review, with some photographs, of the sculptural metal percussion instruments made by Peter Englehart.

THE MAZZEO CLARINET by Richard Bush, in Technicom, Vol. 11 # 5, Oct.-Nov. 1987 (PO Box 51, Normal, IL 61761).

The author discusses improvements in clarinet design introduced by Selmer in the late 50s -- namely, the addition of a separate register vent. The instrument was a commercial failure despite being acoustically superior, and the author suggests that this is due to people's reluctance to accept anything new. He goes on to provide information on performance and repair work for anyone who happens across such an instrument.

SUHIRJAN: MUSICIAN AND GAMELAN MAKER by Joan Bell Cowan, in **Balungan** Vol. III #1, November 1987 (Box 9911, Oakland, CA 94613).

The author looks at the work of one respected gamelan builder. price and purchasing information is included.

THE CONSTRUCTION, TECHNIQUE, AND IMAGE OF THE CENTRAL JAVANESE REBAB IN RELATION TO ITS ROLE IN THE GAMELAN by Colin Quigley, in **Pacific Review of Ethnomusicology**, Vol. 3 (1986) (Music Dept., UCLA, Los Angeles, CA 90024).

TECHNICAL TOPICS by Norman Rehme, in **Glass Music World** Vol. II #1, January 1988 (2503 Logan Drive, Loveland, CO, 80538).

Two interesting topics are touched on in this column: glues for bonding glass to metal, and aspects of pitch perception in glass instruments.

ALIQUOT SCALES by Michael Sloper, in 1/1, Vol. 4 #1 (535 Stevenson St., San Francisco, CA 94103).

Aliquot scales are scales created by spacing tone holes on a wind instrument or frets on a string instrument equally -- for example, Aliquot 12 results when one divides the total string length by 12 and places frets accordingly. This article is an exploration of Aliquot scales and their implications.

American Lutherie #12, Winter 1987 (8222 S Park Ave, Tacoma, WA. 98408) is full, as usual, of interesting material:

THE SAMI-SEN, by Nicholas Von Robison, presents plans for building the Japanese Sami-sen, traditional long lute with a catskin sound table.

HISTORICAL LUTE CONSTRUCTION: THE ERLANGEN LECTURES, by Robert Lundberg, is a historical discourse followed by building plans for one of the instruments discussed.

ELECTRIC VIOLINS: THE NEW FRONTIER, by George Manno, is an overview of recent developments in electric violin design.

INNOVATION IN THE ELECTRIC GUITAR by Paul Helmer discusses the topic with an emphasis on the general atmosphere for innovation in electric guitar design over the years. One of the author's main conclusions is that while large companies dominate commercial guitar making, the most important innovations have come from individuals.

A PORT BUT NO PINS by William McCaw, LOST SHIRTS AND CURVED BRACES by Harry Fleishman, and TAP IT AND TUNE IT, by David Freeman, all are articles on the development of a viable acoustic bass guitar, happening before our eyes in the pages of **American Lutherie**.

AT THE OUTER LIMITS OF SOLID GEOMETRY: LEO BURRELL'S "TWISTED NECK" GUITAR is a reprint of a recent letter from Leo Burrell to Tim Olsen of AL, describing a guitar with a neck which rotates 45 degrees between the nut and bridge.

Some new publications have come to our attention which we will briefly mention here:

THE STRING INSTRUMENT CRAFTSMAN is another luthier's publication, with an emphasis on guitars. It's put out by GPI Corporation, the same people who produce **Keyboard, Guitar Player** and other music publications. That backing is reflected in the fact that the layout of the first issue (Jan/Feb 1988) is professional looking and, as it happens, quite nice. The first issue is very short at 12 pages. Price is $15.95 for six issues, from The String Instrument Craftsman, 20085 Stevens Creek Blvd., Cupertino, CA 95014.

MUSICAL SAW NEWS came out this January with its second issue. It is a photocopied newsletter of 6 stapled pages. Most of the news included relates to saw festivals. Unlike **Sawing News of the World** (the other sawing newsletter), it doesn't seem to be affiliated with any manufacturer. Available for $4/year from **Musical Saw News**, PO Box 84935, San Diego, CA 92138-4935. How often does it come out? Doesn't say, as far as I can see.